by Claire Koelsch Sand

Packaging Expands Fresh Produce Access

Access to fresh produce has changed drastically during the past few decades, and consumers are taking advantage of it.

They expect to find their favorite fresh fruits and vegetables year-round at supermarkets and other locations, such as convenience stores and quick-serve restaurants in both rural and urban environments. Nearly 60% of consumers say they are purchasing a larger variety of produce now than 10 years ago, according to *The Packer's Fresh Trends 2021* report, and 54% ate more fresh produce items during the past year. Institutional access to large quantities of fresh produce also has increased with the adoption of fresh produce within school lunch programs, hospitals, and other large organizations.

This expanded access requires that texture, flavor, and safety be maintained in fresh produce for longer periods of time, and packaging innovations are helping to make that happen in the entire value chain.

In-Field Packaging

Packaging produce in the field into retail-ready packaging reduces the amount of handling and damage. This increases shelf life and is especially beneficial for fragile produce, such as strawberries, raspberries, and blueberries.

Performed by a temporary harvest labor force, in-field packaging is a rapid process requiring packaging that resists weather conditions such as rain, facilitates ease of product entry and measuring, is spacious enough to accommodate agriculturally variable fruit sizes, and can be closed readily and securely. A one-piece polyethylene terephthalate clamshell container that features side and top vents allows for rapid cooling and the exchange of gases. Molded pulp tubs and containers are also commonly used. Moisture absorbent pads on the package bottom or integrated into the package structure adsorb excess moisture and water loss from produce known as weeping.

Other produce is packed in bulk in the field within retail-ready corrugated cases or reusable crates so that labor at retail is minimized. For example, chile harvested in the Hatch and Mesilla valleys in New Mexico is shipped to markets in cases or crates, then roasted by the retailer or the consumer to remove the peel before the chile is eaten.

Controlling Respiration

Packaging for some fresh produce requires specific package permeability parameters to allow the exchange of oxygen, carbon dioxide, and ethanol generated during postharvest respiration.

Modified atmosphere gases and package barrier requirements that optimize the shelf life of produce are dependent on a number of factors, including cultivar, season, location, and weather (Lee 2021). A high barrier, however, does not always result in extended shelf life. For example, a superior barrier will result in fast-respiring tomatoes undergoing anaerobic glycolysis and will shorten their shelf life considerably. But a poor barrier will allow tomatoes to ripen from green to red in time for consumer purchase. To control respiration rates and maturation, a controlled exchange of gases is needed, and this is accomplished with modified atmosphere environments as well as laser-cut holes on flexible lidding and bags.

Topseal Reseal *resealable lidding has antifog capability and can match the optimal respiration rate of different produce.* Photo courtesy of Belmark

Edible Packaging Advantages

Coatings on fruits and vegetables help retain moisture and limit microbial growth for many years. Oil-based coatings help retain value by inhibiting moisture loss from fresh produce sold by weight, such as apples, pears, and oranges.

Other produce is commonly coated with a multitude of antimicrobial coatings or packaged within secondary or tertiary packaging containing mold inhibitors. (See "Antimicrobial Packaging on the Rise Again" in the October 2020 issue of *Food Technology*.) Water loss is a factor when food waste from produce is measured by weight, and produce that is susceptible to mold growth is of particular concern because toxins can result from this growth. For example, patulin derived from bruised apples results in apples that cannot be consumed as whole fruit. Interestingly, these unusable apples are used to create alcoholic apple ciders, since the fermentation process reduces the amount of toxin to below risk levels.

Produce Mix Packaging Solutions

When fresh fruits and vegetables are combined, packaging

requirements become more complex. For example, salad kits and salad blends—which saw a 21% dollar sales increase in 2020 compared with 2019, according to IRI—include a multitude of foods that respire at different rates, such as Curation Foods' *Eat Smart Sweet Kale Vegetable Salad Kit*. The *Eat Smart* product contains broccoli stalks, cabbage, brussels sprouts, kale, and an assortment of foods at different water activities, such as dried cranberries and pumpkin seeds, in addition to dressing with internal pouches.

This necessitates a refined use of different fresh processing treatments and packaging respiration rates to ensure shelf life is fulfilled. While some components of salad kits are packaged individually within the larger package, applying edible coatings to the different components can eliminate the need for separate packaging. Selection of optimal coatings relates to the water activity (gradient, moisture content, texture, and mode of deterioration) of the components in the salad kit.

Distribution-Friendly Package Design

Corrugated cases and reusable trays/crates on pallets frequently are used to transport fresh produce to retailers. Controlled temperatures and atmosphere chambers, along with shipping containers such as trailers, airplanes, ship cargo holds, and rail cars, extend the shelf life of this produce.

Airflow is essential within most tertiary produce packaging to allow for rapid initial cooling, introduction of modified atmosphere gases to control the rate of maturation, and venting of ethylene and moisture. Hole profiles on cases—and the cases themselves—are oriented on pallets to maximize airflow. In addition, microholes in flexible produce bags inhibit contamination and allow for a more rapid exchange of water vapor, oxygen, and ethylene than with even poor barrier bags.

Shock and vibration encountered during global shipping is also a major concern. Fragile fruits such as fresh mangoes, for example, which may mature while they are being shipped, require additional packaging. They are commonly packaged within expanded polyethylene or corrugated mesh, on pulp trays molded to conform to a mango-like shape. Handling of irregularly shaped produce is labor intensive throughout distribution and retail. Banding produce, such as bananas, into groups that can be readily divided and rotated reduces retail and distribution labor costs.

Intelligent Temperature Monitoring

During transit to retail, fresh produce can experience temperature extremes within warehouses, at outside loading docks, and on trucks, ships, airplanes, and trains. Because temperature correlates directly with produce shelf life and safety, and some fresh produce cannot be exposed to freezing conditions, temperature commonly is monitored with temperature-based intelligent packaging.

Packaging requirements *become more complex when fresh fruits and vegetables are combined in products, such as in salad kits.* © Global Stock/E+/Getty Images

Packaging produce in the field into retail-ready packaging reduces the amount of handling and damage, increasing shelf life.

Three interrelated types of intelligent packaging—temperature, integrators, and track and trace—can ensure produce safety and reduce food and packaging waste. For example, *Emerson* time, temperature, and humidity sensors use wireless, USB, or NFC to monitor pallet loads. On-package sensors that indicate temperature abuse include *Thermax* and *Freeze Watch*.

The industry is rapidly adopting microbial growth indicators and time and temperature integrators that match the growth kinetics of critical microbes within specific produce. When a foodborne illness outbreak occurs, track and trace intelligent packaging traces the source of the outbreak from farm to fork. Rapid and focused recall reduces the magnitude of food safety outbreaks, pinpointing the specific issue quickly and eliminating productwide produce recalls in favor of specific recalls.

Post-Purchase Protection

Extending produce shelf life after consumer purchase is just as critical as extending shelf life from farm to retail and reduces the amount of inedible produce that consumers discard. Once packaging is opened, produce shelf life often decreases rapidly.

Solutions such as resealable packaging, or flexible packaging that can be conformed to the shape of the remaining product in large bags of lettuce, broccoli, and green beans, increase shelf life. Alternatively, portioning produce into smaller sizes means the package is opened only once at use, optimizing headspace and

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allowing the modified atmosphere packaging to remain in the closed smaller package. Package design that allows for produce to be readily seen within the refrigerator can also help ensure produce is consumed while still fresh.

Looking ahead, research is underway to extend produce shelf life for consumers, including the release of phages and hydrogels to regulate moisture.

Consumer Features Boost Packaging Appeal

Consumer convenience features add value to produce packaging too. For example, steam-in-bag produce packaging uses the bag microholes to vent moisture and facilitate some steaming, allowing for less dishware to be used and producing optimal steaming temperatures. Edible produce stickers ensure that produce unfit for consumers can be readily converted into juices or incorporated into food scrap composting without the cumbersome removal of stickers from decaying produce.

Innovative paper-based design allows produce preservation while satisfying consumer interest in reducing polymer-based primary produce packaging. The Belmark *Sealutions* lidding film portfolio, for example, can replace rigid plastic clamshell lidding by sealing to a variety of containers, including fiber-based trays and punnets, reducing the plastic content in the package by at least 35%.

"This lidding is capable of macro- or precisely controlled micro-laser perforations for engineered transmission, and can offer package resealability as well as antifog windows to view produce," says Jason Vande Loo, director of business development-strategic products/markets for Belmark. "Our in-house analytical capabilities determine the respiration rate of different fresh produce varieties to maximize shelf quality and mitigate food waste. This is achieved with Belmark's exclusive and patented *Fresh Technology* platform. Additionally, the edge-to-edge graphics and print quality on lidding film vs. a label on a rigid thermoform is a brand differentiator." **FT**

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